

Notes from EIC task force / ePHENIX / eSTAR
coordination meeting 9 May 2013

Instigation is charge from ALD Berndt Mueller for STAR and PHENIX to present LOI's for how to use first-stage eRHIC collisions; specifically 10 GeV electron beam, sketch out detector well enough to be able to be costed; want to see answer by September 30.

Today is just beginning; want to understand what observables are required to be measured, what ePHENIX and eSTAR can best start with.

Elke: Physics agenda is described well in EIC white paper. Also, EIC Wiki pages are resource for many plots and calculations.

Start with presentation from Dave Morrison.

Don't plan to start by taking dedicated eRHIC detector and paring it back, but start with STAR/PHENIX and build up. EA: note that dedicated full detector designed for both Stage I and Stage II of eRHIC.

Stepping through components drawn in dedicated eRHIC detector, understand what drives the need for them.

1. HCAL in e- direction; what does it do? EA: almost nothing for Stage I eRHIC [PWS: presumably one only gets significant hadron energy in the electron direction when electron energy is much higher, Stage II eRHIC?], though there could be hadrons in e- direction for very low Q^2 interactions and calorimeter useful for electron purity & identification; question of background rejection for what survives E/P matching electron ID.

2. EMCal and RICH in e- going direction; do you need it when electrons are few and well-separated? EA: Again, not designed for Stage I, this level of electron reconstruction needed for Stage II; could be staged in building an experiment, though JN points out that Berndt's charge did not instruct us to describe staging or stage-ability. Thomas U: EIC white paper presumed Stage-I, Stage-II eRHIC plan but this is now out of favor, no official "Stage II" is in plan. Xangbu: still need dense electron ID for background processes such as conversions; estimate need ~2% energy resolution at 1 GeV.

AE: figure of merit is "survivability" in (x, Q^2) bins, judge when rate in one bin unacceptably leaks into neighboring bins.

Discussion of whether pre-shower is useful, or called for; whole EM stack could be quite small if pulled in close to IR, combine tracking with resolution within pre-shower for angle. JN: tracking coverage needed for background rejection from non-vertex sources, independent of momentum reconstruction need.

3. Tracking on e- going side. Diagram of lepton angle versus Q^2 ; choice of Q^2 sets angular range you need to cover with best momentum resolution via tracking. For

example, if you give up $Q^2 < 1 \text{ GeV}^2$ then detector can be only outside 5 degrees off the beam. Note that dedicated detector plans for tracking at η of 4.5, about 2 degrees off the beam. An important bit of physics that would be lost if low-angle electrons aren't tracked is diffractive production of J/Ψ 's; they appear at mid-rapidity but need scattered electron for kinematics, i.e. to get "t". Note that all diffractive cross sections are sharply peaked at low Q, as $1/Q^6$; steeper than DIS, which goes as $1/Q^4$.

Dedicated detector design has upstream low- Q^2 tagger, to see electron in cases of $Q^2 < (0.1 \text{ GeV})^2$; it's a small calorimeter. General question from JN, if don't need RICH, then how well can main EMCal see at low angles as it is brought inward in Z? Range of 2 - 5 degrees off beam line opens $1 \text{ GeV}^2 < Q^2 < 0.1 \text{ GeV}^2$.

4. Magnetic field. What drives choice of 3T solenoid field?

A: enough magnetic kick to do tracking at forward angles, well enough for charged hadron PID; want hadron reconstruction in rapidities from at least 1, ideally to 3, over full pT range; out to rapidity 4 would be even better but very difficult. Without PID you lose semi-inclusive physics, i.e. to get basic singles spectra of charm, vector mesons, etc. for parton physics (GPD's, DVCS, etc.).

Question of what's needed for charged hadron PID at mid-rapidity (big circle on Dave's slide at this point); dE/dx is not as good in PHENIX tracking compared to STAR TPC and sPHENIX is too compact for TOF to help, so points toward need for DIRC / proximity focussing RICH in mid-rapidity region. AE: need study to see if we can get by without DIRC in eSTAR evolution, maybe high-resolution TOF instead; but not at all demonstrated yet.

JN: Cost scaling for DIRC? AE: Not knowable, only one example of working DIRC, in different configuration.

5. High-resolution inner tracker, i.e. silicon. What is the big need for it? is it just charm & bottom? A: Yes, basically, plus some "private" ideas. Discussion: how compelling is physics program without displaced vertex measurement? can you get by with topological D or B reconstruction? Discussion; some extra sensitivity to gluons if F_2 of charm can be measured reliably, for example.

JN: general question, how can any of these channels be triggered on? beyond just finding the scattered electron, especially for a hadronic semi-inclusive final state.

6. RICH and PID in hadron-going direction. Here the energy resolution requirement is much less demanding, ordinary $15\%/\sqrt{E}$ would suffice. Still want RICH for hadron ID, maybe it's really combined with AGEL, etc.

General question about need for radiation hardness; not from beam interactions, but synchrotron radiation from e- beam.

7. HCal in hadron-going direction? Main purpose is for forward jet reconstruction in diffractive events, jets can get up to $\sim 50 \text{ GeV}$ lab energy and tracking will not suffice (as we well know).

Question of what advantage there could be to the beams if the experiment is reduced in Z extent; general conclusion seems to be that improvement is small at best once experiment is smaller than 9m in Z.

JN: Thinking about upgrading sPHENIX to ePHENIX, two big differences compared to the dedicated eRHIC detector design, are (i) lower planned field, 2T in sPHENIX instead of 3T in dedicated plan, and (ii) sPHENIX more compact in radial extent, basically ~1m out to EMCal versus ~2m. These have big implications for tracking and PID. sPHENIX can change these, but only at very considerable cost; and any extra cost to sPHENIX to accommodate later ePHENIX is not paid for by EIC funds! at least in current plan.

Thinking in terms of stages, even if not politically official: if eRHIC starts collisions in 2025 then equivalent of Stage-II might not start before 2035, plenty of time to build new trackers, etc.
AE: very little guidance so far in planning for upgrades, detector evolution with time.

Problem, to some degree, is again that LOI charge does not include stage-ability above 10 GeV electron beam, even though future for higher energy e- beams are always thought to be in the plan. Pay early or pay later? how to cost sensibly, even for dedicated detector design.

JN: Is there also a charge to the design for the dedicated detector, to show a Stage-I version by September, that the DOE wants to compare to eSTAR and ePHENIX? A: No, next planned stage for dedicated detector is TDR, on time scale of end of calendar 2013. Of course, BNL will have to make sure to have coherent approach, may look strange to have dedicated experiment TDR in parallel with eSTAR and ePHENIX LOI's progressing to proposals.

Costing note: using an existing hall, e.g. 1008, instead of building dedicated detector in new hall at IP-12, saves on order \$100M. So strong motivation to plan dedicated detector at one of the existing big halls.
TU: Current eRHIC plan only includes one IR, this is what goes into \$500M cost figure; need additional \$40-50M to get e-hadron collisions at second IR, completely aside from experiment. But keep in mind that the \$500M plan keeps full current RHIC hadron-hadron capability.

JN: general question, could eSTAR and ePHENIX be co-designed to be complementary? if neither can easily cover the whole/most eRHIC physics program, e.g. not both need to do charm. (Need to remember, that \$50M doesn't buy so much these days!)
AE: Minimum requirement is that both experiments would need very good reconstruction of the primary scattered lepton.

What next? One thing, need to make sure that the physics agenda pointed to in the LOI charge is fairly fixed and

can be referred back to (drawback of Wiki page format); Berndt wants EIC TF to produce new list, beyond the existing EIC white paper.

EIC task force meets nearly every week; suggest to have next coordination meeting in 3 weeks from now, which would be the 30th? maybe 23rd would be better? Not that hard to dial in for an hour. Try for May 30, just to be definite.

How to be informed? anyone can subscribe to EIC task force e-mail list.